# ELECTRIC VACUUM CLEANER

## CROSS REFERENCE TO RELATED APPLICATION

The present application is based on Japanese Priority Document JP2002-302682 filed on October 17, 2003, the content of which is incorporated herein by reference.

## BACKGROUND OF THE INVENTION

### FIELD OF THE INVENTION

The present invention relates to an electric vacuum cleaner, and particularly to a battery-operated electric vacuum cleaner.

### DISCUSSION OF THE BACKGROUND

In a battery-operated electric vacuum cleaner provided with a motor-driven blower, a method for increasing an input to the motor-driven blower is generally known as a method for increasing the output of the motor-driven blower to enhance dust suction capability. As a specific example, there is known a method for changing windings of a motor-driven blower, increasing current inputted to the motor-driven blower, and boosting or stepping up a power supply voltage to thereby increase an input to the motor-driven blower.

When an attempt is made to increase an input current where the motor-driven blower is made up of a commutator motor, a carbon of a brush portion that makes contact with a commutator is worn, and the brush portion

becomes apt to be damaged due to sparks or the like at the commutator. It is therefore hard to ensure reliability.

As a method for boosting the power supply voltage in the case of the battery-operated electric vacuum cleaner, a method for increasing the number of batteries is the simplest. However, in a case of requiring a high voltage, when only the batteries are used, each of the batteries becomes large-sized.

Therefore, there has heretofore been proposed a method for obtaining a high voltage by use of a step-up converter circuit to solve such an imperfection or trouble (For example, JP7-322971 and JP8-224198).

For example, JP8-224198 discloses a technology for providing a switching means for switching a power supply for supplying power to a motor-driven blower to any one of a commercial power source and a secondary battery and gradually raising a boosted voltage from a low voltage to a predetermined voltage upon boosting.

Meanwhile, a technology for coordinating use states of a step-up converter circuit and an electric vacuum cleaner equipped with the step-up converter circuit to thereby enhance dust suction performance is extremely important to the electric vacuum cleaner.

It is known that the load on the motor-driven blower greatly varies depending on the relationship between, for example, an inlet of the electric vacuum

cleaner and a target to be cleaned.

It is known that the electric vacuum cleaner equipped with the step-up converter circuit has a drawback that in a voltage boosting or step-up process at the operation of the step-up converter circuit, a power loss occurs due to a switching element or the like of a booster or step-up circuit.

Therefore, there has been a demand for an effective operation of the step-up converter circuit according to the state of a load on the electric vacuum cleaner to cover the drawback such as the power loss with a view toward enhancing dust suction performance and lengthening the usage time of a battery per charge.

However, the technology described in JP8-224198 referred to above describes only that there is provided the switching means for switching the power supply for supplying power to the motor-driven blower to any one of the commercial power source and the secondary battery and the boosted voltage is gradually raised from the low voltage to the predetermined voltage upon boosting. Thus, the present technology does not disclose the state of a load and the operation of the step-up converter circuit. No suggestion thereof is provided either.

## SUMMARY OF THE INVENTION

Accordingly, an object of the present invention is to provide an electric vacuum cleaner equipped with a

step-up converter circuit with a DC power supply as a drive source, wherein the step-up converter circuit is operated with satisfactory efficiency based on the state of a load on the electric vacuum cleaner to thereby enhance dust suction performance of the electric vacuum cleaner and lengthen the usage time of a battery per charge.

The object of the present invention is achieved by a novel electric vacuum cleaner of the present invention.

Thus, according to the novel electric vacuum cleaner of the present invention, such an electric vacuum cleaner equipped with a step-up converter circuit with a DC power supply as a drive source drives and controls the step-up converter circuit so as to refer to such a relationship inputted in advance to a memory means as to decrease a variation in dust suction capability, determine an output voltage to be boosted according to the state of a load on a motor-driven blower, boost the output voltage, based on the result of determination and supply power to the motor-driven blower, thereby activating the step-up converter circuit with satisfactory efficiency.

## Brief Description of the Drawings

A more complete appreciation of the present invention and many of the attendant advantages thereof will be readily obtained as the same becomes better

understood by reference to the following detailed description when considered in connection with the accompanying drawings, wherein:

Fig. 1 is a perspective view showing an outward appearance of an electric vacuum cleaner illustrated as one embodiment of the present invention;

Fig. 2 is a circuit diagram illustrating one example of a control circuit of the electric vacuum cleaner shown in Fig. 1;

Fig. 3 is a circuit diagram depicting a circuit for a voltage converting means of the electric vacuum cleaner shown in Fig. 1;

Fig. 4 is a circuit diagram showing a configurational example of a voltage conversion control means of the electric vacuum cleaner shown in Fig. 1;

Fig. 5 is a timing chart illustrating a pulse signal and a triangular wave;

Fig. 6 is an explanatory view depicting one example of operation control of the electric vacuum cleaner shown in Fig. 1;

Fig. 7 is a graph showing the characteristic of the electric vacuum cleaner shown in Fig. 1;

Fig. 8 is a vertical sectional side view illustrating an internal configuration of the electric vacuum cleaner shown in Fig. 1;

Fig. 9 is a typical diagram for describing a data table stored in a storage means;

Fig. 10 is a typical diagram for describing a data table stored in the storage means;

Fig. 11 is a flowchart illustrating one example of boost rate control of the electric vacuum cleaner shown in Fig. 1;

Fig. 12 is a typical diagram for describing a data table stored in the storage means;

Fig. 13 is a flowchart showing one example of boost rate control of the electric vacuum cleaner shown in Fig. 1;

Fig. 14 shows an inlet body, wherein Fig. 14(a) is a bottom view thereof, and Fig. 14(b) is a circuit diagram for detecting its attachment/detachment;

Fig. 15 shows an inlet body, wherein Fig. 15(a) is a bottom view thereof, and Fig. 15(b) is a circuit diagram for detecting its attachment/detachment;

Fig. 16 is a perspective view showing a crevice tool and a brush attached to the inlet body; and

Fig. 17 is a circuit diagram illustrating another example of the voltage converting means of the electric vacuum cleaner shown in Fig. 1.

## DETAILED DESCRIPTION OF THE INVENTION

A first embodiment of the present invention will be described with reference to Figs. 1 through 17.

[External configuration]

Fig. 1 is a perspective view showing an external

configuration of an electric vacuum cleaner according to the embodiment of the present invention. As shown in Fig. 1, the electric vacuum cleaner 1 according to the present embodiment includes a hose body 4 detachably mounted to an inlet 3 attached to a case 2.

A dust cup 5 used as a dust chamber, a motor-driven blower 6, and a DC power supply (see Fig. 2) are provided within the case 2. A plurality of exhaust ports 8, which communicate with the motor-driven blower 6 and are open in substantially front side directions, are defined in side plate portions of the case 2. A handle 9 used as a knob means is provided on its corresponding upper surface of the case 2. The handle 9 is formed so as to take a substantially Y-shape as seen in a plane surface. A display means 10 provided with a plurality of light-emitting diodes is disposed in the vicinity of the handle 9.

Also charge terminals (not shown) set to a charging bed or base for thereby supplying power to the DC power supply 7 to charge the DC power supply 7 are provided at a substantially central portion of the rear face of the case 2.

The hose body 4 has an inlet body 11 provided at its leading end, and an extension pipe 12 that causes the inlet body 11 and the inlet 3 to communicate with each other. The hose body 4 is detachably connected to the inlet 3 such that the base end of the hose body 4 communicates with the suction side of the motor-driven blower 6 through the dust

cup 5 used as the dust chamber. The extension pipe 12 is a flexible connecting pipe. Thus, the hose body 4 has flexibility. The inlet body 11 is provided with an unillustrated rotating cleaning body (rotating brush) rotated under an electric operation or the flow of air.

The hose body 4 is provided with a hand control 13 used as an operation means having a bent shape. The hand control 13 is provided with an operation mode switching controller 14 that functions as a controller at a position where it can be operated by the operator's fingers.

The operation mode switching controller 14 shares the use of a power switch of the motor-driven blower 6 and is configured so as to be able to select a plurality of types of operation modes for respectively bringing the motor-driven blower 6 to different driven states. Described specifically, as shown in Fig. 2, a control button (switch for stop) 14a for stop setting corresponding to an operation mode, a control button 14b for low operation setting corresponding to an operation mode, and a control button 14c for high-operation setting corresponding to an operation mode are sequentially arranged side by side in a line within the operation mode switching controller 14 in the direction of the extension pipe 12 as viewed from the hose body 4.

In the present embodiment, the interior of the case 2,the interior of the extension pipe 12 and the interior the hose body 4 are constituted as a space that assumes

negative pressure or vacuum according to the operation of the motor-driven blower 6. Therefore, the inlet body 11 is in communication with the space that assumes the negative pressure according to the operation of the motor-driven blower 6.

[Control circuit]

A configuration of a control circuit with respect to the motor-driven blower 6 employed in the electric vacuum cleaner 1, and its operation will next be explained with reference to Figs. 2 through 6.

The motor-driven blower 6 provided within the case 2 is connected to a power supply circuit comprising the DC power supply 7 and a voltage converting means 33. The DC power supply 7 is chargeable via the charge terminals (not shown) referred to above. The voltage converting means 33 boosts or steps up a voltage outputted from the DC power supply 7 and outputs the stepped-up or boosted voltage to the motor-driven blower 6.

A switching part (A) 24 is connected between the DC power supply 7 and a main circuit 33a for the voltage converting means 33. The switching part (A) 24 is an electromagnetic relay or a semiconductor switching element such as a bipolar transistor or the like. The switching part (A) 24 is controlled by an electric vacuum cleaner control means 25.

The electric vacuum cleaner control means 25 comprises a motor-driven blower control means 30, a voltage

conversion control means 28, a DC power supply monitoring means 27, a memory or storage means 26, a load detecting means 29, a voltage reading means 31, and an AD converter 32, and the like. The electric vacuum cleaner control means 25 controls the whole electric vacuum cleaner 1. The operation mode switching controller 14, the display means 10, a thermistor 21 for measuring the temperature of the DC power supply 7, a rechargeable battery identifying means 34, a section 22 (corresponding to a section for detecting an output voltage of a rechargeable battery) for detecting a voltage inputted to the voltage converting means 33, a section 23 (corresponding to a section for detecting a voltage inputted to the motor-driven blower 6) for detecting a voltage outputted from the voltage converting means 33, a current detecting section 37, and a negative pressure detecting section 39 (see Fig. 8) that functions as the load detecting means 29, and the like are connected to the electric vacuum cleaner control means 25. The negative pressure detecting section 39 will be described later.

The electric vacuum cleaner control means 25 may be made up of a plurality of circuit components and a plurality of microcomputers, or may be configured with a one-chip microcomputer as the center.

Although described later, the DC power supply 7 includes a rechargeable battery 7a. A series circuit of a resistor R1 and a resistor R2 is connected to the

rechargeable battery 7a. The electric vacuum cleaner control means 25 is connected to the voltage converting means input-voltage detecting section 22 provided between these resistors R1 and R2. A voltage divided by the resistors R1 and R2 is inputted to the electric vacuum cleaner control means 25.

Similarly, a series circuit of a resistor R3 and a resistor R4 is connected between both ends of the motor-driven blower 6. The electric vacuum cleaner control means 25 is connected to the voltage converting means output-voltage detecting section 23 provided between these resistors R3 and R4. Thus, a voltage divided by the resistors R3 and R4 is inputted to the electric vacuum cleaner control means 25.

The motor-driven blower control means 30 performs switching to the switching part 24 in accordance with the operation of each control button of the operation mode switching controller 14 to thereby control the output of the motor-driven blower 6.

[Description of DC power supply]

The DC power supply 7 will next be described. The DC power supply 7 for supplying power comprises the rechargeable battery 7a in which batteries such as nickel cadmium batteries, nickel hydrogen batteries, lithium ion batteries are connected in series in plural form, the thermistor 21, a resistor R0 used as the rechargeable battery identifying means 34, and a thermostat 35, and the

like.

A plus terminal of the rechargeable battery 7a is connected to one end of the thermostat 35. The other end of the thermostat 35 is connected to one end of the resistor R0.

[Description of operation mode switching controller]

A specific configuration of the operation mode switching controller 14 and its operation will next be explained.

In the electric vacuum cleaner control means 25, a voltage-divided value of a reference voltage V1 changes according to the state of operation of the operation mode switching controller 14. In the electric vacuum cleaner control means 25, the voltage-divided value varied according to the operation state is converted into a digital signal by the ADC 32 corresponding to an analog/digital converter, followed by being read by the voltage reading means 31.

A circuit configuration (voltage variable circuit) for allowing the voltage-divided value of the reference voltage V1 to change according to the operation state of the operation mode switching controller 14, will be described below. The voltage-divided value of resistors R5 and R6 is first inputted to the ADC 32. Then, switches 35a, 36b and 36c are provided which are switched by operating the respective control buttons 14a, 14b and 14c of the operation mode switching controller 14. Resistors R7, R8

and R9 respectively different in resistance value, which are respectively connected to the switches 36a, 36b and 36c, are parallel-connected to the resistor R6. Accordingly, the voltage-divided value of the reference voltage V1 changes according to the operation of each of the control buttons 14a, 14b and 14c of the operation mode switching controller 14.

A control program or a control value or the like associated with each voltage value read by the voltage reading means 31 has been stored in the storage means 26 provided in the electric vacuum cleaner control means 25. Thus, the electric vacuum cleaner 1 is operated in accordance with the respective control buttons of the operation mode switching controller 14.

Thus, the operation mode switching controller 14 is capable of selecting and setting a plurality of voltages. The voltage reading means 31 reads each of the voltages set by the operation mode switching controller 14. A plurality of electric vacuum cleaner operation modes are switched in accordance with the read voltages respectively. Therefore, the addition of each operation mode can be realized at low cost without increasing signal lines for the operation mode switching controller 14 and the ADC 32.

[Description of voltage converting means]

Next, a configurational example of the voltage converting means 33 with respect to the motor-driven blower 6 in the electric vacuum cleaner 1 is shown in Fig. 3. The

voltage converting means 33 comprises a magnetic part 40 such as a reactor that assumes the role of storage and emission of energy, a switching part (Q) 41 using a semiconductor switching element such as a MOSFET, a bipolar transistor or an IGBT, a backflow or reverse-current prevention part 42 (diode) for preventing a back-flow of the energy, a capacitor 43 used as a capacitive impedance part element, and the voltage conversion control means 28, etc.

The reactor used as the magnetic part 40 is composed principally of a winding (coil) and a core made of a magnetic material. The core is inserted into the wiring. The switching part (Q) 41 is turned on and off to control current that flows through the wiring. The reactor performs the storage and emission of the energy in accordance with this operation. The core material of the reactor is a magnetic material such as ferrite, Sendust, Permalloy, an amorphous alloy. As the shape of the core, may be mentioned, a solenoid shape, a toroid shape or the like.

The voltage conversion control means 28 controls the operation of the switching part (Q) 41 for increasing or boosting a voltage outputted from the rechargeable battery 7a. That is, the voltage conversion control means 28 has the function of setting the frequency of an on/off pulse signal, and duty defined by an on time/(on time + off time) of the on/off pulse signal and outputting the pulse signal.

A voltage outputted from the main circuit 33a for the voltage converting means is adjusted according to the frequency or duty of the pulse signal outputted from the voltage conversion control means 28. Incidentally, the ratio of the output voltage boosted or stepped up by the voltage converting means 33 to the voltage (voltage inputted to) outputted from the DC power supply 7 is called a step-up or boost rate. That is, the boost rate is expressed in (boost rate) = (output voltage boosted by the voltage converting means 33)/(output voltage of the DC power supply 7). Here, the output voltage from the DC power supply 7 results in the input voltage as viewed from the voltage converting means 33. Therefore, the boost rate may also be represented by (the output voltage boosted by the voltage converting means 33)/(the voltage inputted to the voltage converting means 33).

Described more specifically, the voltage converting means 33 has an input terminal Pa connected to the DC power supply 7 side, a common terminal Pb, and an output terminal Pc connected to the motor-driven blower 6 side. The input terminal Pa is connected to one terminal of the magnetic part (reactor) 40. The other terminal of the magnetic part (reactor) 40 and a drain terminal of the switching part (Q) 41 are connected to each other. A source terminal of the switching part (Q) 41 and the common terminal Pb are connected to each other. The voltage conversion control means 28 is connected to a gate terminal of the switching

part (Q) 41. A point where the reactor 40 and the switching part (Q) 41 are connected to each other, and an anode terminal of the diode 42 are connected to each other. A cathode terminal of the diode 42 and one terminal of the capacitor 43 are connected to each other. The other terminal of the capacitor 43 and the common terminal Pb are connected to each other. A point where the diode 42 and the capacitor 43 are connected to each other, is connected to the output terminal Pc. The boosted voltage of the DC power supply 7 is outputted between the output terminal Pc and the common terminal Pb.

The boosting or step-up operation of the voltage converting means 33 will now be explained. When the switching part (Q) 41 is turned on in response to the pulse signal outputted from the voltage conversion control means 28, a current Is flows so that energy is stored in the reactor 40 by a current IL. Next, when the switching part (Q) 41 is turned off by the voltage conversion control means 28, the energy stored in the reactor 40 flows into the motor-driven blower 6 through the diode 42 as a current Id, followed by being charged into the capacitor 43. By allowing the voltage conversion control means 28 to continuously turn on and off the switching part (Q) 41 in this way, the repetition of the storage of the energy in the reactor 40 and the emission of the energy from the reactor 40 is realized.

The energy stored in the capacitor 43 is not fed

back or returned to the reactor 40 owing to the diode 42. The capacitor 43 is charged with a voltage higher than that of the DC power supply 7, and the charged voltage of the capacitor 43 is supplied to the motor-driven blower 6.

A specific method for adjusting the frequency and duty of the pulse signal outputted from the voltage conversion control means 28 will next be explained with reference to Fig. 4.

In Fig. 4, the operation mode switching controller 14 is operated to activate the voltage conversion control means 28. In the voltage conversion control means 28, signals are inputted to an error amplifier 51 from a reference voltage section 52 and an input voltage section 53 respectively. A signal outputted from the error amplifier 51 and a triangular wave signal oscillated from an oscillation section 54 are inputted to a signal comparator 55. The oscillation section 54, which allows the triangular wave signal to oscillate, is a method conventionally known per se. A pulse signal is outputted from the signal comparator 55 to control the turning on and off of the switching part (Q) 41.

Now, the frequency of the triangular wave signal oscillated from the oscillation section 54 is suitably set to thereby make it possible to control the frequency of the pulse signal. Also the switching part 56 is suitably switched to vary the value of the voltage at the input voltage section 53. It is thus possible to control the

duty of the pulse signal outputted from the signal comparator 55. A switching method of the switching part 56 is stored in the storage means 26.

The method of controlling the frequency and duty of the pulse signal inputted to the switching part (Q) 41 can be realized even by a programming process of a microcomputer. The relationship between the frequencies and duties of the triangular wave signal and pulse signal is illustrated as a timing chart in Fig. 5. The triangular wave signal is digitally generated through the use of a timer counter. In the case of an up/down counter mode, for example, the maximum value TCp1 of a counter value is set to thereby obtain a period Tp(k) of the pulse signal as follows:

$$Tp(k) = 2 \times TCp1 \times \text{timer counter clock [sec]}$$

Thus, the frequency fp(k) of the pulse signal is given as follows:

$$fp(k) = 1/2(2 \times TCp1 \times \text{timer counter clock}) \text{ [Hz]}$$

Further, a set value S(k) stored in the storage means 26 and the value of the timer counter are compared. When the timer counter's value (triangular wave signal) reaches greater than or equal to the set value S(k), the pulse signal is set so as to assume ON. Consequently, a pulse width PW(k)[sec] is determined and hence a duty Du(k) is represented as follows:

$$Du(k) = PW(k)/(2 \times TCp1 \times \text{timer counter clock}) [\%]$$

The maximum value TCp1 of the timer counter value

and the set value S(k) are changed to control the frequency fp(k) and duty Du(k) of the pulse signal. A method of changing these set values is stored in the storage means 26.

Thus, as shown in Figs. 4 and 5, at least one of the frequency and duty of the pulse signal is controlled to make it possible to control the boost rate of the voltage converting means 33. For instance, the duty is raised to increase the boost rate, and the duty is reduced in reverse to decrease the boost rate.

[Description of operation]

The operations of the electric vacuum cleaner 1 and voltage converting means 22 where the low control button 14b, high control button 14c and stop control button 14a are operated in the operation mode switching controller 14 of the control circuit shown in Fig. 2 to which the voltage converting means shown in Fig. 3 is applied, will now be described in detail with reference to Fig. 6 together with the operations of the switching part (Q) 41 and switching part (A) 24.

When the low control button 14b is first operated in the electric vacuum cleaner 1 in a halt state, an on signal is outputted from the motor-driven blower control means 30. The switching part (A) 24 performs an on operation, based on the signal, so that the motor-driven blower 6 starts to rotate. Thus, the output of the motor-driven blower 6 rises from a zero output to a pre-set low operation mode output P1.

When the high control button 14c is operated from this state, the voltage conversion control means 28 outputs a pulse signal to the switching part (Q) 41. The voltage converting means main circuit 33a is operated in response to the pulse signal, so that the output voltage of the rechargeable battery 7a is stepped up, followed by being applied to the motor-driven blower 6. Then, the output of the motor-driven blower 6 is raised up to a pre-set high operation mode output P2.

When the stop control button 14a is operated from this condition, the voltage conversion control means 28 stops the output of the pulse signal. Then, the switching part (Q) 41 is turned off so that the voltage converting means main circuit 33a is deactivated. Further, the switching part (A) 24 s turned off by the motor-driven blower control means 30 so that the motor-driven blower 6 is deactivated.

As illustrated in the present operation example, a process for controlling the switching operation of the switching part (Q) 41 constitutes a switching means for selecting any one of the output voltage of the DC power supply 7 and the output voltage boosted by the voltage converting means 33 together with the switching part (Q) 41.

However, according to the present embodiment, when the high control button 14c is operated, the output voltage boosted by the voltage converting means 33 is

supplied to the motor-driven blower 6. Therefore, a deboost or non step-up operation mode is set in a low operation mode of "low" and "high" operation modes of the electric vacuum cleaner 1. On the other hand, a boost or step-up operation mode is set in the high operation mode of the low and high operation mode of the electric vacuum cleaner 1. In this sense, the control button 9 for low operation setting functions as a control section for selecting the non step-up operation mode. On the other hand, the control button 14c for high operation setting functions as a control section for selecting the step-up operation mode. In addition, the stop button 14a functions as a stop control section for stopping the rotation and driving of the motor-driven blower 6.

Although not illustrated in particular, a bypass path for directly supplying the voltage of the DC power supply 7 to the motor-driven blower 6 may be provided without using the path of the voltage converting means main circuit 33a in the non step-up operation mode. In this case, it is possible to eliminate losses in the reactor 40 and diode 42 of such a voltage converting means main circuit 33a as shown in Fig. 3.

An example of a method for controlling the voltage converting means 33 in a step-up operation mode shown in Fig. 6 will next be described. A user uses the electric vacuum cleaner under various circumstances. For example, the user cleans above a carpet, a mat, and a floor, or

detaches the inlet body 11 and the extension pipe 12 for their cleaning. Due to the differences among targets to be cleaned, the state of a load applied to the electric vacuum cleaner 1 changes and the state of output of the electric vacuum cleaner 1 also changes.

Fig. 7 shows an airflow Q vs. negative pressure H characteristic of the electric vacuum cleaner 1 and an airflow Q vs. power P characteristic thereof where the boost rate of the voltage converting means 33 is changed. The power P of the electric vacuum cleaner 1 can be calculated from the airflow Q and the negative pressure H. The suction force of the electric vacuum cleaner 1 that a user feels, significantly depends on the power P. Since the airflow of the electric vacuum cleaner 1 (the loaded state thereof) is determined due to the difference between targets to be cleaned, operating points H1 and P1 in Fig. 7, for example, result in an operating point at a certain target (airflow Q1) to be cleaned in the case of the boost rate e. Thus, this operating point is also shifted if the target to be cleaned is changed.

Also as shown in Fig. 7, the characteristic of the electric vacuum cleaner 1 varies for each boost rate of the voltage converting means 33. Thus, in the present invention, the state of a load is detected by the load detecting means 29, and the boost rate of the load detecting means 33 is changed based on the detected value to thereby shift the operating point of the electric

vacuum cleaner 1 onto the characteristic at another boost rate.

As one example of control on the above, such a control example that when the airflow Q changes and the power P of the electric vacuum cleaner 1 is reduced, the boost rate is raised and the power P of the electric vacuum cleaner 1 is maintained at a certain constant level, is illustrated in Fig. 7. The characteristics at five types of boost rates are shown in the figure. As a matter of course, drawn trajectories of operating points become smooth by finely changing the boost rates.

When the electric vacuum cleaner 1 is in use, the inlet body 11 and the extension pipe 12 are pressed against a surface to be cleaned or spaced away therefrom. The airflow Q changes depending on this operation. Thus, it is so effective for the load detecting means 29 to determine the airflow Q and automatically increase or decrease the boost rate of the voltage converting means 33 according to the determined airflow Q to thereby control the power P of the electric vacuum cleaner 1, from the viewpoint that a high suction force is acquired when necessary. Since the motor-driven blower 6 is not operated all the time at a high boost rate, the consumption of battery energy is suppressed and the continuous use time per charge can also be rendered long.

As a method for detecting the state of a load applied to the electric vacuum cleaner 1 by the load

detecting means 29, there is known, for example, a method for detecting the airflow Q and the negative pressure H in the electric vacuum cleaner 1 or a method for detecting current that flows through the motor-driven blower 6. For example, the negative pressure detecting section 39, which functions as the load detecting means 29, is installed within an upstream air path of the motor-driven blower 6. Described more specifically, as shown in Fig. 8, a negative pressure detecting section 39 (39a) is provided in an air path between the inlet 3 and the dust cup 5. Alternatively, a negative pressure detecting section 39 (39b) is provided in an air path between the dust cup 5 and the motor-driven blower 6. The negative pressure detecting section 39 can be realized by a pressure sensor, for example. Incidentally, although the dust cup 5 of cyclone dust collection type is illustrated in the present embodiment, a method such as a paper bag type may be adopted as the dust collection type.

And as an another method for detecting the state of a load, an airflow detecting section which provided at the same part of the negative pressure detecting section 39a, 39b detects each flow velocity (m/s). And, the airflow detecting section calculates airflow from a cross section ($m^2$) of an air path which is provided at the negative pressure detecting section 39a, 39b. And, the airflow detecting section detects the state of a load applied to the electric vacuum cleaner 1.

A data table showing the relationship of correspondence between the negative pressure and the airflow set every boost rates such as shown in Fig. 9 is prepared in the storage means 26 in advance on the basis of such a relation as shown in Fig. 7. By referring to the data table, the airflow can be grasped based on the negative pressure detected by the negative pressure detecting section 39. In addition to such a data table as shown in Fig. 9, the relationship between the negative pressure and the airflow may be defined using a relational expression. Data about such a table or relational expressions have bee stored in the storage means 26.

Now, an example of a data table descriptive of input voltages, boost rates, and values for an airflow range employed in the voltage converting means 33 is shown in Fig. 10. In the present data table, the boost rates are respectively set according to the input voltages of the voltage converting means 33. When the rechargeable battery 7a is used as the DC power supply 7, the voltage of the battery is reduced with the use of the electric vacuum cleaner 1 after its charge. Therefore, the boost rates are set every input voltages of the voltage converting means 33 so that operation modes of various specs can easily be realized.

In the case of, for example, an operation mode in which the continuous use time per charge is long, the

boost rate is also changed small each time the input voltage of the voltage converting means 3 drops.

Also in the case of, for example, an operation mode in which emphasis is placed on the magnitude of a suction force, the boost rate is not changed small even if the input voltage of the voltage converting means 33 is reduced.

Fig. 11 shows one example of a control flow for changing the boost rate of the voltage converting means 33 according to the state of a load on the electric vacuum cleaner 1 through the use of the data tables shown in Figs. 9 and 10.

The maximum negative pressure Hmax is first set (Step S101). Next, the maximum output voltage Voutmax of the voltage converting means 33 is set (Step S102), and an input voltage Vin of the voltage converting means 33 is detected (Step S103). If the input voltage Vin of the voltage converting means 33 is larger than a lower limit voltage from the result of its detection (Y in step S104), then the data table is retrieved in accordance with the its detected value (Step S105) and a boost rate (duty) and an airflow ranges Qdwn and Qup are set (Step S106). Thereafter, a step-up operation is started (Step S107).

Then, an output voltage Vout of the voltage converting means 33 is detected (Step S108). If the output voltage Vout is greater than an upper limit voltage Voutmax (Y in step S109), then the negative

pressure H1 is detected (Step S110). When the detected value of the negative pressure H1 is larger than the previously set Hmax (N in step S111), the step-up operation is stopped (Step S115). Described more specifically, this operation is supposed to be taken in abnormal conditions such as a case in which the air path of the electric vacuum cleaner 1 is blocked off by a large refuse or the like. When the air path of the electric vacuum cleaner 1 is blocked off by the large refuse or the like, the negative pressure in the electric vacuum cleaner 1 rises. Thus, needless power consumption can be suppressed owing to this operation.

On the other hand, when the negative pressure H1 is detected (Step S110) and its detected value is smaller than the previously set Hmax (Y in step S111), the airflow Q1 is estimated from its detected value H1 and such a data table as shown in Fig. 9 (Step S112).

If the estimated airflow Q1 is larger than the airflow range value Qdwn and smaller than Qup (Y in step S113), then the boost rate is not changed.

On the other hand, if the estimated airflow Q1 is smaller than the airflow range value Qdwn or larger than Qup (N in step S113), then the boost rate is changed to a large value (Step S114), and the control flow is returned to Step S106. By increasing the boost rate in this way, the power P of the electric vacuum cleaner 1 is enhanced and the suction force increases. Increasing the value of

the boost rate is performed by, for example, increasing the duty of a pulse signal outputted from the voltage conversion control means 28. Such a control flow is repeatedly executed.

It is so effective from the viewpoint that a high suction force is acquired when necessary, to automatically increase or decrease the boost rate of the voltage converting means 33 according to the state of a load to thereby control the power P of the electric vacuum cleaner 1.

Since the motor-driven blower 6 is not activated all the time with a high boost rate, the consumption of battery energy is suppressed and the continuous use time per charge can also be lengthened.

Here, the state of pressing of the inlet body 11 against a surface to be cleaned, of use forms of the electric vacuum cleaner is a well-known circumstance. In the state in which the inlet body 11 is being pressed against the surface to be cleaned, the airflow Q1 is reduced and the negative pressure H increases, as compared with the state in which the inlet body 11 is being spaced away from the surface to be cleaned.

Accordingly, the magnitude of the suction force at this time is one performance so important to a user. Thus, it is so effective for a sweeper to automatically increase the boost rate of the voltage converting means 33 and enhance the power P where the inlet body 11 is

pressed against the surface to be cleaned so that the quality of air Q is reduced.

As another control example, it may be feasible to detect a current that flows through the motor-driven blower 6 to thereby grasp the state of a load and control the output voltage of the voltage converting means 33 according to the value of the detected current. An example of a data table descriptive of input voltages, boost rates and values for current ranges of the voltage conversion means 33, which are used in this control, is shown in Fig. 12. Data about such a table or relational expressions are stored in the storage means 26.

Incidentally, the current that flows through the motor-driven blower 6 is detected by the current detecting section 37 constituted of, for example, a current transformer and a shunt resistor as shown in Fig. 2.

Fig. 13 shows another example of the control flow for varying the boost rate of the voltage converting means 33 according to the state of a load applied to the electric vacuum cleaner 1 through the use of the data table illustrated in Fig. 12.

First of all, the minimum current Imin, the maximum current Imax, and the maximum output voltage Voutmax of the voltage converting means 33 are set (Steps S201 and S202). Next, an input voltage Vin of the voltage converting means 33 is detected (Step S203). If the input

voltage Vin is greater than a lower limit voltage Vd (Y in step S204), then a boost rate (duty) and current ranges Idwn and Iup are set according to the value of the detected voltage Vin (Step S206). Afterwards, a step-up operation is started (Step S207). Then, an output voltage vout of the voltage converting means 33 is detected (Step S208). If the value of the detected voltage is smaller than the maximum output voltage Voutmax (Y in step S209), then a current I1 is detected (Step S210). When the detected value I1 is smaller than the previously set Imin or larger than the previously set Imax (N in step S211), the step-up operation is stopped (Step S214). This is supposed to be taken where the electric vacuum cleaner 1 lapses into an abnormal state.

On the other hand, when the current value I1 is detected and the value of the detected current is larger than the previously set Imin and smaller than the previously set Imax (Y in step S211), it is next compared with the current range values (Step S212).

If the detected value of current I1 is larger than the range value Idwn and smaller than the range value Iup (Y in step S212), then the boost rate is not changed.

On the other hand, when the detected current value I1 is smaller than the range value Idwn or larger than Iup (N in step S212), the boost rate is changed to a large value (Step S213).

By increasing the boost rate in this way, the power

P of the electric vacuum cleaner 1 is enhanced and the suction force increases.

As described above, it is so effective from the viewpoint that a high suction force is acquired when necessary, to automatically increase or decrease the boost rate of the voltage converting means 33 according to the state of the load to thereby control the power P of the electric vacuum cleaner 1.

Since the motor-driven blower 6 is not activated all the time with a high boost rate, the consumption of battery energy is suppressed and the continuous use time per charge can also be lengthened.

Incidentally, as shown in Fig. 14, a cleaned surface detecting means 80 may be provided on the suction side of the inlet body 11 mounted to a leading end of an air path. When, for example, the cleaned surface detecting means 80 is made up of a mechanical switch and the inlet body 11 is pressed against the surface to be swept, the switch is turned on so that a signal is inputted to the electric vacuum cleaner control means 25. The voltage conversion control means 28 controls the boost rate according to the input signal.

One example of its control is described. When the signal is inputted from the cleaned surface detecting means 80 during cleaning, the electric vacuum cleaner control means 25 judges that the airflow Q is reduced and the negative pressure H is increasing, and controls the

boost rate to increase it.

Consequently, the electric vacuum cleaner control means 25 is capable of indirectly grasping the state of a load in accordance with the signal of the cleaned surface detecting means 80.

Incidentally, the cleaned surface detecting means 80 can be realized even by another type of switch such as an optical switch.

As described above, the state of pressing of the inlet body 11 mounted to the leading end of the air path against the surface to be cleaned, of the use forms of the electric vacuum cleaner is a well-known circumstance.

The magnitude of the suction force in the state in which the inlet body 11 is pressed against the surface to be cleaned, is one performance so important to a user.

Therefore, it is so effective for a sweeper to automatically increase the boost rate of the voltage converting means 33 when the inlet body 11 is being pressed against the surface to be cleaned.

Since the boost rate is not increased at random when the inlet body 11 is not brought into contact with the surface to be cleaned, the continuous use time per charge can be lengthened.

Here, the rate of increase in the boost rate may be fixed, i.e., the boost rate may be increased at a predetermined proportion. The rate at which the boost rate is raised according to the input voltage of the

voltage converting means 33, may be changed. When the rate of increase in the boost rate is fixed, that is, the boost rate is increased at the predetermined proportion, control on the boost rate can be simplified.

Incidentally, when the inlet body 11 is not in contact with the cleaned surface, the electric vacuum cleaner control means 25 may control the step-up operation of the voltage converting means 33 so as to avoid its step-up operation. Described specifically, when the inlet body 11 is spaced away from the surface to be cleaned, and the mechanical switch is turned off, the electric vacuum cleaner control means 25 automatically stops the step-up operation.

The continuous use time per charge can be lengthened by performing the step-up operation only when necessary without always performing the step-up operation.

Detection is made as to whether such an inlet body 11 as shown in Fig. 15 is connected to the extension pipe 12, the hose body 4 or the case 2 or the like, whereby the state of a load can be indirectly grasped and hence the boost rate can be controlled. Described specifically, when a connecting plug 81 mounted to the inlet body 11 is detached from the extension pipe 12, the hose body 4 or the like, the resistance of wiring changes. The change in the resistance thereof is detected by the electric vacuum cleaner control means 25. It is thus possible to detect whether the inlet body 11 is connected to the extension

pipe 12, the hose body 4 or the case 2 or the like. Here, the function of an attachment/detachment detecting means is executed.

Thus, owing to the provision of the attachment /detachment detecting means for detecting the presence or absence of the state of attachment/detachment of the inlet body 11 at the tip of the air path, the electric vacuum cleaner control means 25 changes the boost rate according to a signal outputted from the attachment/ detachment detecting means.

When the inlet body 11 is detached, for example, the electric vacuum cleaner control means 25 controls the boost rate of the voltage converting means 33 so as to increase it. Of use forms of the electric vacuum cleaner, the state in which as shown in Fig. 16, the inlet body 11 is detached, and a crevice tool 60 or a brush 91 is attached to the tip of an air path of the extension pipe 12 or the hose body 4 or the like to thereby perform cleaning, is a well-known circumstance. The magnitude of a suction force at this time is one performance so important to a user. Thus, it is so effective to automatically increase the boost rate of the voltage converting means 33 when the user has detached the inlet body 11 (the inlet body 11 is detached). The rate at which the boost rate increases, may be fixed. Alternatively, the rate at which the boost rate increases, may be changed according to the input voltage of the

voltage converting means 33. In the case of its fixing, control on the boost rate can be simplified.

The above embodiment shows an example in which the low control button 14b and a high control button 9d are sequentially operated from a halt state, based on Fig. 6. That is, it illustrates an example in which a non step-up operation mode is switched to a step-up operation mode. As a matter of course, the high control button 9d may directly be operated at the halt state. In this case, the operation mode is switched to the step-up operation mode directly from the halt state.

Thus, the non step-up operation mode for supplying a voltage outputted from the DC power supply 7 to the motor-driven blower 6 and the step-up operation mode for supplying an output voltage obtained by boosting the output voltage of the DC power supply 7 to the motor-driven blower 6 are prepared in advance. Further, a switching means for selecting these operation modes and an operation mode switching control section for operating the switching means are provided. Consequently, the user is able to carry out direct switching in person.

On the other hand, when the power supply voltage is boosted by the voltage converting means 33, a loss in power by each circuit part or component or the like that constitutes a voltage converter occurs. Therefore, a drawback arises in that needless power is inevitably used as compared with a case in which the electric vacuum

cleaner is directly driven by the battery.

However, there is provided a feature that a power supply unit can be significantly made small-sized and lightened as compared with a case in which the capacity of the battery is increased in size.

Where the voltage of the battery is boosted by the voltage converting means, the user makes use of the voltage converting means even under the condition in which dust suction capability is not required, when the voltage converting means is always operated, thus causing a loss in power due to the use of the voltage converting means and shortening the service or usage time of the battery. When the battery is of a rechargeable battery, the usage time per charge becomes short.

On the other hand, as in the present embodiment, a (non step-up operation mode) means for driving the motor-driven blower by an output voltage of a battery alone, which is applied to a case in which the dust suction capability is not so required or it is desired to make long the usage time (usage time per charge in the case of a rechargeable battery) of the battery, and a (step-up operation mode) means for driving the motor-driven blower by an output voltage boosted by the voltage converting means, which is applied to a case in which high dust suction capability is needed, are provided as means for controlling the output of the motor-driven blower. Further, there is provided a switching means capable of

selecting these output control means whenever necessary. Consequently, the user is able to select the corresponding operation mode according to user's various circumstances.

As a matter of course, such a configuration that the step-up operation mode is selected, may be adopted even if any one of the low control button 14b and the high control button 14c is operated. In this case, such table data as shown in Fig. 9, 10 or 12 is provided for the respective control buttons. Alternatively, when any one of the control buttons is operated, the boost rate is fixed.

[Another configurational example of voltage converting means]

Another configurational example of the voltage converting means with respect to the motor-driven blower 6 in the electric vacuum cleaner 1 will next be described with reference to Fig. 17. In a voltage converting means 60 employed in the present embodiment, a transformer 61 having a primary winding 61a and a secondary winding 61b is used as a magnetic part. The primary winding 61a and the secondary winding 61b of the transformer 61 are reversely connected.

Described more specifically, the voltage converting means 60 has an input terminal Pa and an input-side common terminal Pd connected to the DC power supply 7, and an output terminal Pc and an output-side common

terminal Pe connected to the motor-driven blower 6. The voltage converting means 60 is configured as follows: The input terminal Pa and one terminal of the primary winding 61a of the transformer 61 are connected to each other. The other terminal of the primary winding 61a of the transformer 61 and a drain terminal of a switching part (Q) 41 are connected to each other. A source terminal of the switching part (Q) 41 and the input-side common terminal Pd are connected to each other. The output side of a voltage conversion control means 28 is connected to a control terminal of the switching part (Q) 41. One terminal of the secondary winding 61b of the transformer 61 is connected to an anode terminal of a diode 42. A cathode terminal of the diode 42 and one terminal of a capacitor 43 are connected to each other. The other terminal of the capacitor 43 and the other terminal of the secondary winding 61b of the transformer 61 are connected to each other. A point where the diode 42 and the capacitor 43 are connected, is connected to the output terminal Pc. A connecting point of the capacitor 43 and the secondary winding 61b of the transformer 61 is connected to the output-side common terminal Pe. A voltage obtained by boosting the output voltage of the DC power supply 7 is outputted between the output terminal Pc and the output-side common terminal Pe.

A boost or step-up operation of such a voltage converting means 60 will be explained. When the switching

part (Q) 41 is turned on in response to a pulse signal outputted from the voltage conversion control means 28, a current IT1 flows so that energy is stored or accumulated in the transformer 61. Since, at this time, the primary winding 61a and the secondary winding 61b of the transformer 61 are reversely connected, no current flows into the secondary side owing to the diode 42.

Next, when the switching part (Q) 41 is turned off by the voltage conversion control means 28, a back electromotive voltage occurs in the corresponding winding of the transformer 61 so that the potential is inverted. Therefore, the energy stored in the transformer 61 is discharged into the secondary winding 61b side (motor-driven blower 6 side) through the diode 42 as a current IT2. A voltage higher than the DC power supply 7 is charged into the capacitor 43 and then supplied to the motor-driven blower 6.

Obviously, numerous modifications and variations of the present invention are possible in light of the above teachings. It is therefore to be understood that within the scope of the appended claims, the invention may be practiced otherwise than as specifically described herein.